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REPORT ON WATER QUALITY AND PUBLIC HEALTH ASPECTS OF THE PROPOSED SENATOR WASH PROJECT

PUBLIC HEALTH SERVICE
DENVER, COLORADO

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REPORT ON WATER QUALITY AND PUBLIC HEALTH ASPECTS OF THE PROPOSED SENATOR WASH PROJECT

PREPARED IN COOPERATION WITH THE
BUREAU OF RECLAMATION, REGION 3
BOULDER CITY, NEVADA

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Water Supply and Pollution Control
Region VIII
Denver, Colorado

Colorado River Basin Water Quality Control Project
April 1963

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PART I - STREAM QUALITY ASPECTS

INTRODUCTION

Following a conference with the Bureau of Reclamation, Region 3, Boulder City, Nevada in August 1962, and a November 29, 1962 letter from the Bureau confirming the work to be carried out, the Public Health Service initiated a study to determine the need for and value of storage in Senator Wash Reservoir for the regulation of streamflow for the purpose of water quality control. This study was made in accordance with Public Law 84-660 (as amended by Public Law 87-88), section 2b. The report includes the results of a study of general public health and vector control aspects of the project. The preliminary vector evaluation was prepared jointly by personnel of the Communicable Disease Center, Public Health Service, and the Bureau of Vector Control, California State Department of Public Health.

The assistance and recommendations concerning the report, of the Arizona State Department of Health and the California State Department of Public Health are gratefully acknowledged.

SUMMARY AND CONCLUSIONS

1. Salinity is a serious problem in the Colorado River below the confluence of the Gila River and is caused primarily by drainages originating with the Wellton-Mohawk Irrigation and Drainage District along the Gila River.

2. Water uses of the Colorado River at Yuma, Arizona have been seriously affected by high salinity in the Colorado River.

3. The population of the City of Yuma has increased from 5,325 in 1940 to 23,974 in 1960. Population projections indicate that approximately 70,000 persons may be expected by the year 2010. However, a permanent and satisfactory solution for the Yuma water quality problems must be put into effect so that the future growth of the City is not adversely affected.

4. Bacteriological densities in the Colorado River below Yuma, Arizona are in excess of desirable limits and are caused primarily by the discharge of raw sewage from the City of Yuma, Arizona.

5. Reduction of flows in the Colorado River by the Senator Wash Project without controlling salinity from the Wellton-Mohawk area, would be expected to:

   a. Increase total dissolved solids concentration in the Colorado River at Yuma, Arizona approximately 21 percent over present values, on an annual average basis. Individual monthly averages would show increases of 6 to 40 percent.

b. Increase the annual chloride concentration in the Colorado River at Yuma, Arizona approximately 27 percent. Individual monthly averages would show chloride increases ranging from 6 to 50 percent over existing values.

c. Increase the annual average concentration of total dissolved solids by approximately 6.5 percent at the northerly United States-Mexico border. Monthly average concentrations would increase 1 to 36 percent for individual months.

d. Increase the chloride concentrations 12 percent on an annual average basis at the northerly United States-Mexico border. Individual monthly averages would increase 3 to 60 percent.

6. Reduction of flows in the Colorado River below Imperial Dam may increase the problems associated with the sludge discharged from the desilting basins of the All-American Canal system.

P. 8

7. The Public Health Service concurs with the conclusion of the Arizona State Department of Health that it would be completely improper to further damage the quality of water at the municipal water intake at Yuma, Arizona by reducing the flow in the Colorado River with the Senator Wash Project.

8. Storage of water in the Senator Wash Project for mineral quality control cannot be recommended until satisfactory control measures have been placed into effect for controlling salt discharges from the Wellton-Mohawk Irrigation and Drainage District at the source. Following the institution of control measures at the source, the need for storage for water quality control can be reevaluated.

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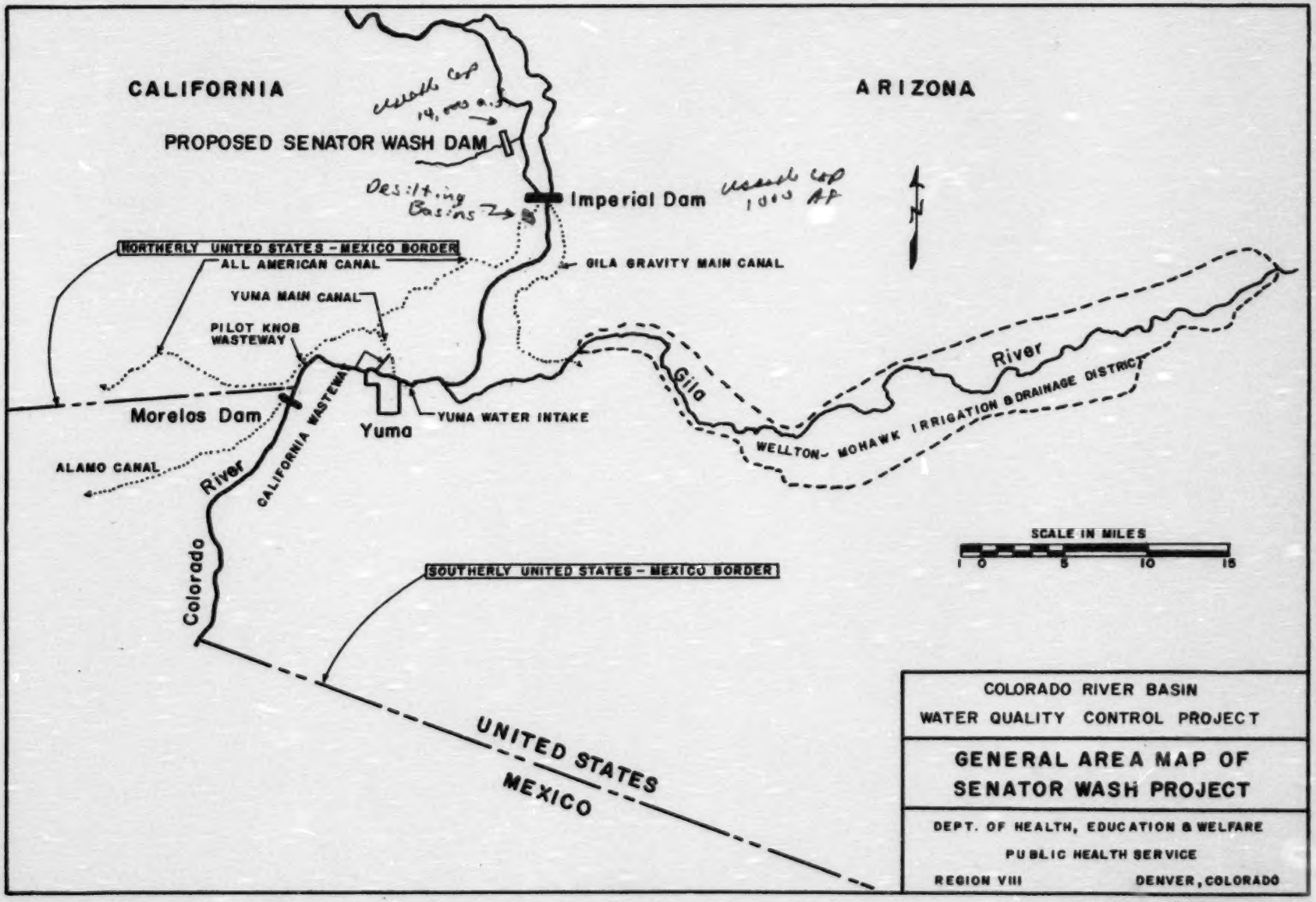
type of control suggestion

DESCRIPTION OF PROJECT

The purpose of the project is to provide storage of surplus flows, in the Colorado River at Imperial Dam, and to release the water as needed to fill downstream requirements in the United States and Mexico (See Figure 1). Off-stream storage just above the Imperial Dam for regulation of the flow would permit closer scheduling and more accurate releases. At present, irrigation water must be ordered and released 3 to 4 days in advance from Parker Dam, the last control point on the Colorado River above Imperial Dam. Sometimes, upon arrival at Imperial, the quantity released becomes surplus because of unexpected rains, change of temperature and humidity, etc. in the Yuma area and Imperial Valley. Under existing conditions the surplus water would flow to Mexico if it cannot be diverted into the All-American Canal or Gila Gravity Main Canal at Imperial Dam. Since Imperial Dam is a diversion dam rather than a storage dam, it has a limited capacity for storage.

Senator Wash Dam

Senator Wash Dam would be located 22 miles north of Yuma, Arizona and 2 miles northwest of Imperial Dam on the California side of the Colorado River. Fourteen thousand acre-feet of water could be stored behind the 70-foot high earth dam, of which 2,000 acre-feet would be dead storage.



COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT

GENERAL AREA MAP OF SENATOR WASH PROJECT

DEPT. OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

GPO 833562 FIGURE 1

It has been estimated by the Bureau of Reclamation that approximately 170,000 acre-feet of water can be saved annually by the United States with the Senator Wash Project. This would be accomplished by pumping water from Imperial Reservoir into Senator Wash Reservoir during periods when surplus flows are available and releasing the water back to Imperial Reservoir as needed. This operation would result in a lower flow in the Colorado River below Imperial Dam on the majority of days of the year.

DESCRIPTION OF THE STUDY AREA

The study area is defined as that portion of the Colorado River from the point where the proposed pumping station for Senator Wash Reservoir will be located to the northerly boundary between the United States and Mexico.

The climate of the study area is warm and is typical of the desert of southwestern Arizona and adjacent parts of California. The nearest weather station is at Yuma Test Station, U. S. Army, about 4 air miles southeast of the proposed dam site. During the period 1957-1961, the only period when records are available, the precipitation ranged between 2.18 and 5.65 inches. Recorded temperatures between 30 and 117 degrees Fahrenheit were measured. Highest temperatures are generally experienced in the area from May through September, with relatively high humidity during July and August. Severe thunderstorms occur during late summer which are characterized by relatively short duration and high concentration.

Yuma, Arizona (1960 population 23,974) is the only major community in the study area. It is located about 8 river miles above the northerly international boundary. The Gila River enters the Colorado about 5 miles above Yuma.

Much of the study area along both sides of the Colorado River is in irrigated agriculture. On the Arizona side the lands are in irrigation from Yuma downstream to the Mexican border, and upstream from Yuma to about 8 miles north of the Gila River. On the California side of the Colorado River about 10,600 acres of land in the Reservation Division of the Yuma Project are in irrigation. The water for all of these irrigated lands is diverted upstream at Imperial Reservoir. These diversions are expected to continue indefinitely.

The bed of the Colorado River from Imperial Dam to the Mexican border is almost entirely shifting sand with many visible sand bars. Because of this condition, very little recreational use is made of this section of the river.

ECONOMICS AND POPULATION

Population growth trends are major indicators of the overall economic growth of an area. Yuma, Arizona is the center of present economic activity in the study area and future growth is expected to take place in this vicinity.

The population in Yuma, Arizona has increased steadily at a high rate during the past two decades. The following table compares Yuma's population growth with the State of Arizona 1940 to 1960.

POPULATION TRENDS OF YUMA, ARIZONA
and
THE STATE OF ARIZONA, 1940 - 1960

Area	Year	Total Population	Percent Increase 1940-1960	1950-1960	1940-1960
City of Yuma	1940	5,325			
	1950	9,145	71.7		
	1960	23,974		162.2	350.2
Arizona	1940	499,261			
	1950	749,587	50.1		
	1960	1,302,161		73.7	160.8

The projected population growth rate of Yuma, Arizona is expected to continue at a higher rate than the State of Arizona and the United States. Only three highly urbanized areas in the State (Phoenix, Tempe, and Tucson) have exceeded Yuma's growth rate during the past decade. Population projections for Yuma are estimated at 3 times the 1960 level or approximately 70,000 persons by the year 2010.

Civilian labor force by major industry groups indicating percentage change 1950 to 1960 is shown in Table I. Major increases in labor force requirements are anticipated in the manufacturing industries. Agricultural activity will continue as a leading industry in the area's economy. Mining activity has been a minor segment of the economy and is not expected to continue to increase in importance. The secondary industries, such as transportation, communications, utilities, the trades, and services will increase in importance to the local economy in proportion to the basic industries.

Expenditures by tourists and travelers add significantly to the area's source of basic income. The economic additive of these expenditures to the local economy are reflected primarily through their impact on the retail and service categories. Future development in activities oriented to outdoor recreation are expected as a result of Yuma's attractive climate, accessibility, and increasing facilities.

Employment in Government activities has expanded rapidly during the past decade as shown in Table I. A continuing increase in the contribution of local, State, and Federal government activity is expected throughout the projection period; however, a slower rate is anticipated during the latter half.

TABLE I

CIVILIAN LABOR FORCE BY MAJOR INDUSTRY GROUPS
Yuma, Arizona, 1950 - 1960

Industry	1960	%	1950	%	% of Change 1950-1960
Agriculture	444	4.9	155	4.2	186.5
Forestry & Fisheries	-	-	-	-	-
Mining	8	.1	17	.5	52.9
Construction	707	7.9	354	9.5	99.7
Manufacturing	381	4.2	170	4.5	124.1
Trans. Comm. & Pub. Utilities	1,135	12.6	721	19.3	57.4
Wholesale & Retail Trade	2,113	23.5	995	26.6	112.0
Finance, Ins., & Real Estate	355	4.0	112	3.0	217.0
Business & Repair Services	265	3.0	105	2.8	152.4
Personal Services	738	8.2	295	7.9	150.2
Entertainment & Recreation	90	1.0	48	1.3	87.5
Professional & Related Services	939	10.4	302	8.1	210.9
Public Administration	1,137	12.7	165	4.4	589.1
Industry not Reported	230	2.6	20	.5	1,050.0
Total Employed	8,542	95.1	3,459	92.6	146.9
Unemployed	444	4.9	275	7.4	61.5
Total	8,986	100.0	3,734	100.0	140.7

Source, U. S. Census of Population

Military installations have a major impact on the Yuma economy. Recently expanded facilities indicate a continued economic additive for many years hence.

Future economic development of the balance of the study area, exclusive of the vicinity of Yuma, is not expected to change significantly from the present.

The above projected increases in economic development of the Yuma, Arizona area are based on the assumption that water of suitable quantity and quality will be available. The existing contract that the City of Yuma has for 50,000 acre-feet of water annually is expected to be adequate for the projected economic development and growth. This water is available to the City at Imperial Reservoir. However, unless a permanent and satisfactory solution for the Yuma water quality problems is found and put into effect, the future growth of the City may be adversely affected.

WATER QUALITY AND STREAMFLOW REGULATION

Chemical quality of the water has been a serious problem in the Colorado River below the confluence of the Gila River since December 1960. Prior to 1960 although the water at this location was above the desirable limit of 500 ppm total dissolved solids, it was still usable by the City of Yuma, Arizona. The present problem is caused primarily by salinity[1/] originating with the Wellton-Mohawk Irrigation and Drainage District along the Gila River. When the drainage from the Wellton-Mohawk area reaches the Colorado River, the concentrations of salts in this river increases sharply (total dissolved solids from 958 mg/l to 2,730 mg/l and chlorides from 149 mg/l to 1,025 mg/l).

As a result of the increased salinity, the City of Yuma was forced to abandon its water intake in the Colorado River for its municipal water and is now obtaining water under a temporary arrangement from the Yuma Main Canal.

There are no known present diversions of the Colorado River below the Gila River in the United States, but the river is used in Mexico for domestic, municipal, and irrigation purposes. The Colorado River below Imperial Dam is used to a limited extent for sport fishing, mostly for catfish, mullet, and carp. The excessive silt load in this section apparently discourages game species. Future uses of the river depend on the correction of the salinity, silt, and bacterial problems.

1/ In this report the words "salinity" and "salts" refer to the total dissolved inorganic constituents.

Downstream from the temporarily abandoned Yuma water intake, a relatively large amount of water enters the Colorado River from the California Wasteway and Pilot Knob Wasteway (generally 1,000 to 5,000 cfs). Much smaller amounts of water are discharged by several other wasteways and drains. The water from the California and Pilot Knob Wasteways is better quality (total dissolved solids 826 mg/l and chlorides 118 mg/l) and serves to dilute the concentration of salts in the Colorado River at the northerly United States-Mexico border.

Based on a study of the operation of Senator Wash Reservoir[1/], the Bureau of Reclamation estimated the reduction in flow in the Colorado River at the northerly United States-Mexico border. Based on these figures, the expected salinity in the Colorado River at Yuma and at the northerly United States-Mexico border after the Senator Wash Project is in operation was calculated. These calculations assume that the flows in the Pilot Knob and California Wasteways and Wellton-Mohawk drainage would remain essentially the same as at the present time and the reduction in flow of the Colorado River due to the Senator Wash Project would show up at Yuma as well as the northerly United States-Mexico border. The concentrations of salts as calculated by the Public Health Service, are listed in the following table.

	Colorado River at Yuma, Arizona		Colorado River at northerly U. S.-Mexico border	
	Present	After Project	Present	After Project
Total dissolved solids				
Annual avg., mg/l	2,730	3,310 (Range 2440-4420)*	1,540	1,640 (Range 1270-2770)*
Percent increase		21 (Range 6-40)*		6.5 (Range 1-36)*
Chlorides				
Annual avg., mg/l	1,025	1,300 (Range 880-1840)*	430	480 (Range 320-1080)*
Percent increase		27 (Range 6-50)*		12 (Range 3-60)*

*The range is the minimum and maximum monthly average value during the year, and depends on the amount of water released from upstream.

1/ Data for Preparation of Feasibility Design and Estimate - Senator Wash Dam and Pumping Plant, Pump Storage Projects, California-Arizona, U. S. Department of the Interior, Bureau of Reclamation, July 1962.

Because of the water entering the Colorado River from the California and Pilot Knob Wasteways, the increase in concentrations of dissolved constituents in the river at the northerly United States-Mexico border would be less pronounced than the increases in the river at Yuma, Arizona, as shown in the table.

It is possible that the proposed reduction of flow in the Colorado River below Imperial Dam may result in insufficient water to flush the silt from the desilting basins of the All-American Canal system down the river. This may result in sludge banks and make dredging operations or a different means of disposing of the sludge from the desilting basins necessary. It is assumed that the Bureau of Reclamation will check on this possibility.

DO & BOD no problem

Raw municipal sewage is discharged to the Colorado River by the City of Yuma, Arizona. This amounts to approximately 4.5 million gallons per day during the winter season to 10.4 million gallons per day during the summer. Public Health Service data indicate that the density of coliform organisms reaches an average of 17,400 coliforms per 100 ml at the northerly United States-Mexico border. This value is much above recognized safe limits both for sources of public water supply, and for recreational uses. Public Health Bulletin No. 296, "Manual of Recommended Water Sanitation Practice" indicates a Class III water (requiring complete rapid-sand filtration treatment, or its equivalent, together with continuous post chlorination) as containing numbers of coliform bacteria averaging not more than 5,000 per 100 ml in any 1 month and exceeding this number in not more than 20 percent of the samples examined in any 1 month. Although the Public Health Service has no official bacteriological criteria for waters used for fishing, where standards of bacterial quality have been recommended by water pollution control agencies a limiting value of 5,000 coliforms per 100 ml is generally cited as the monthly average M.P.N.

? Source Calif. W.Q criteria

Sewage from sources in the study area other than Yuma is treated and has a negligible effect on the river.

Reduction or elimination of saline Wellton-Mohawk drainage discharges to the Colorado River, would reduce or eliminate the effects that a reduction of flows in the lower end of the Colorado River by the Senator Wash Project would have on the chemical water quality in the river. Without the saline drainages from Wellton-Mohawk, water quality similar to that existing prior to December 1960 would be available in the Colorado River below Imperial Dam for downstream water uses.

In reviewing the proposed Senator Wash Project, the Arizona State Department of Health made the following statement: 'The aspects of this dam which would be of most concern to us is the additional dewatering of the main-stem below Imperial Dam which it would cause. The amount of return flow from the Wellton-Mohawk Irrigation and Drainage District

would remain unchanged, and thus the degree of degradation of water available to the Yuma water supply would be intensified. It would appear completely improper to further damage the water offered to Yuma, at least until such time as a permanent solution to that city's water problem is worked out."

There have been studies by various agencies directed toward finding an acceptable solution to the problem of degradation of stream quality due to the very poor quality water draining from the Wellton-Mohawk area. The Bureau of Reclamation has proposed measures to reduce salinity at the northerly boundary with Mexico during the periods when Mexico is receiving the lowest flows. The plan proposed would result, however, in higher salinity concentrations at this point during the balance of the year. The total salt load over the 12-month period would remain essentially unchanged.

Section 2(b)(1) of Public Law 660, as amended by Public Law 87-88, states: "In the survey or planning of any reservoir by the Corps of Engineers, Bureau of Reclamation, or other Federal agency, consideration shall be given to inclusion of storage for regulation of streamflow for the purpose of water quality control, except that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source." Storage of water in the Senator Wash Project for mineral quality control cannot be recommended until satisfactory control measures have been placed into effect for controlling salt discharges from the Wellton-Mohawk Irrigation and Drainage District at the source. Following the institution of control measures at the source, the need for storage for water quality control can be reevaluated.

* International Boundary and Water Commission
States
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States.

RECOMMENDATIONS

In order to minimize public health hazards associated with the proposed project, every possible effort should be made to avoid creating conditions which will increase populations of mosquitoes and other arthropods and rodents of public health importance or the exposure of humans to these vectors. It is therefore recommended that the following principles and practices be adhered to in the design, construction, operation, and maintenance of the project.

Responsibility for Vector Control

Responsibility for vector prevention and control is normally associated with land ownership or operating rights. The agency, group, or individuals responsible for various aspects of the proposed project should therefore be prepared to accept full responsibility for the prevention and control of vector problems resulting from the design, construction, operation, or maintenance of the proposed project.

Prevention and Source Reduction Measures

Mosquitoes and Other Aquatic Insects

A. Reservoirs

1. All borrow pits and other potential ponding areas associated with construction of the dam, relocation of highways or roads, etc., which are located above maximum pool level should be made self-draining.

2. Prior to impoundage, the reservoir basin should be prepared as follows:

   a. The normal fluctuation zone of the permanent pool should be completely cleared except for isolated trees and sparse vegetation along abrupt shorelines or in the deeper portion of the pool which will be exposed to wave action.

   b. Borrow pits, depressions, marshes, and sloughs which will be flooded by the reservoir at maximum pool level and which would retain water at lower pool levels should be provided with drains to insure complete drainage or fluctuation of water within them.

   c. If the fluctuation zone of the permenent pool is limited to a few feet, consideration should be given to "building out" mosquito-producing areas by deepening and/or filling of the more extensive shallow water areas located within one and one-half miles of population groups or recreational areas. This would minimize the need for repetitive measures for controlling vegetation and mosquito production.

3. After impoundage, the following maintenance measures should be carried out in all potential mosquito-producing areas located within flight range of human population groups or recreational areas frequented by significant numbers of persons:

   a. All dense vegetation should be removed periodically from flat, protected areas within the normal fluctuation zone of the permanent pool.

   b. Vegetation, debris, and flotage should be removed periodically from all drains to insure free flows.

   c. Drains should be installed to adequately drain seepage areas that develop below the dam.

4. Water level management to minimize conditions favorable for mosquito production should be used to the maximum degree permitted by the primary purposes of the reservoir. This will minimize the need for repetitive measures for controlling vegetation and mosquito production.

5. As a general principle, waterside recreational areas, particularly those which have facilities for overnight human occupancy, should be located along sections of the reservoir which have a low production potential for mosquitoes and other aquatic insects.

B. Waterfowl Refuges

1. Wherever possible, sites selected for waterfowl habitat development should not be within mosquito flight range of population groups or recreational areas.

2. Waterfowl areas which are to be flooded during the mosquito season should be diked or otherwise prepared with abrupt shorelines to preclude shallow water areas favorable for mosquito production.

3. Provision should be made for water level management in waterfowl areas which will minimize mosquito production.

Terrestrial Arthropods and Rodents at Recreational Areas Associated with the Reservoir

1. Proper storage, collection, and disposal of refuse should be practiced in order to prevent and control flies, wasps, other noxious insects, rats, wild rodents, and other small mammals.

2. All buildings should be rodentproofed at recreational areas where rodents are prevalent which may create public health hazards.

3. Debris, rubbish and other materials which may serve as haborage for rodents and other small mammals should be removed periodically.

4. Brush and weeds along paths, trails, roadways, and other areas of frequent use by visitors should be removed in order to reduce the likelihood of tick infection.

Supplemental Chemical Control Measures

In situations where adequate vector control is not obtained through the prevention and source reduction measures outlined above, provision should be made for supplemental use of insecticides and rocenticides to achieve the desired level of control. Insecticides and rodenticides should be applied with appropriate care in order to avoid possible detrimental effects upon recreational activities or upon water quality as related to domestic use and fish and wildlife.

Vector Appraisal

Arrangements should be made for carrying out a routine vector appraisal program as a part of normal operations at the reservoir and the recreational areas associated with it. Inspections for adult and larval mosquitoes and other vectors are essential for planning and evaluating control measures and for adjusting control programs to meet temporary or emergency situations.

NATURE AND EXTENT OF MOSQUITO AND OTHER VECTOR PROBLEMS

Public Health and Socio-Economic Importance

Mosquitoes are the principal vectors which might be affected by the proposed project. Several species of mosquitoes of public health importance may be produced in large numbers in the general project area when suitable aquatic habitats are present. Encephalitis, commonly known as sleeping sickness or brainfever, is now the most important mosquito-borne disease in the United States and the area in which the proposed project will be located. Mosquitoes transmit the encephalitis viruses among birds and from them to humans and horses. There are no effective chemotherapeutic measures for preventing or treating human cases, and some individuals, particularly children, who recover from encephalitis often suffer permanent mental disability.

Records of the U. S. Department of Agriculture show that equine encephalitis cases occurred in Imperial County, California, during 16 years of the 17-year period, 1939 through 1955, for which records are available. During 7 of these years, this county had an incidence in excess of 5 encephalitis cases per 1,000 horses.

Although no human outbreaks of encephalitis have been reported from the area in which the proposed project will be located, the records of equine encephalitis cases indicate that the viruses of this disease are present in the general project area. Both Culex tarsalis and C. quinquefasciatus occur in the area and are considered primary vectors of encephalitis. These mosquitoes are produced in a wide range of aquatic habitats containing either fresh or foul water such as roadside ditches, seepage pools, flooded depressions, and other semipermanent and permanent bodies of water containing emergent vegetation.

Several species of vicious-biting Aedes and Psorophora mosquitoes, including A. dorsalis, A. vexans, and P. confinnis, also occur in the general project area. Large numbers of these mosquitoes may create public health problems by interfering with the healthful outdoor activities of both children and adults during the summer months. Individuals, particularly children, frequently require medical attention and sometimes hospitalization for treatment of secondary infections and alergic reactions resulting from mosquito bites. The Aedes and Psorophora mosquitoes may be produced in temporary surface pools associated with irrigation, and in ponds and reservoirs which have shallow vegetated areas subject to fluctuating water levels. Overflow pools along streams and other temporary surface pools also provide favorable larval habitats for several species of the highly pestiferous Aedes and Psorophora mosquitoes.

In addition to their public health importance, large numbers of biting mosquitoes also cause severe economic losses by lowering meat and milk production, by reducing the efficiency of agricultural and industrial workers, by interfering with recreational enterprises, and by lowering the value of real estate.

Several other groups of aquatic insects may be produced in habitats associated with water resource projects in sufficient numbers to create public health and economic problems. Deer flies and horse flies are often produced along the margins of impoundments and in seeps and marshes in irrigated areas. These insects are vicious biters of both man and livestock and are sometimes involved in the transmission of diseases such as tularemia and anthrax. Several species of small gnats of the family Heleidae are vicious biters and often produce severe reactions and vesicular lesions. These gnats are produced in damp areas of many irrigated valleys as well as alkaline marshes and other wetland areas. Black flies plague both man and livestock with their irritating and painful bites. They normally breed in fast-flowing streams, but are sometimes produced in large numbers in irrigation conveyance systems, particularly drop structures and other water control devices where the flow is relatively fast.

Vectors of terrestrial origin, including arthropods such as ticks, mites, fleas, and flies, and rodents such as ground squirrels, chipmunks, rats, and mice, may be important at recreational sites along the shores of reservoirs. In addition to the irritation, discomfort, and annoyance caused by the arthropod bites, the public health importance of these vectors involves a number of human diseases including Rocky Mountain spotted fever, Colorado tick fever, relapsing fever, tick paralysis, dysentery, typhoid, tularemia, typhus, and plague.

Reservoir Preparation and Water Level Management in Relation to Mosquito Control

The conditions associated with reservoirs which are conducive to mosquito production include emergent vegetation and/or flotage and debris in shallow water areas and embayments that are protected from wave action; undrained depressions, borrow pits, sloughs, and swamps within the fluctuation zone; rising or constant pool levels which cause the water to remain in the marginal vegetation for more than four or five consecutive days during the mosquito breeding season; and marshy seeps below dams.

It is often difficult to control mosquito production on a reservoir that has not been properly prepared prior to impoundage. The principal reservoir preparation measures for mosquito control are clearing and marginal drainage. The overall objective of these measures is to prevent, or minimize, the development of favorable mosquito-producing habitats in any portion of the reservoir which is within flight range of human population.

Reservoir clearing includes removal of trees, underbrush, vines, fences, and debris. For mosquito control purposes it is not necessary to clear timber from the deeper portions of reservoirs where it will be completely submerged at normal minimum pool elevation. Timber rooted below the normal minimum pool level but extending above that elevation may be felled and securely tied down in lieu of disposal. This practice sometimes has advantages in fisheries management. Where clearing operations extend over several seasons, it is sometimes necessary to remove regrowth from the normal summer fluctuation zone immediately prior to impoundage.

All depressions, sloughs, swamps, and marshes in the reservoir basin which would create mosquito-producing areas after impoundage should be provided with drainage ditches. Such drains also serve to prevent the stranding of fish when the main lake recedes. Provision should be made for the removal of logs, drift, and other debris from natual drainageways and existing ditches, where such work is indicated for mosquito control.

Of paramount importance is the fact that the maximum benefits from water level management for mosquito control can be realized only when the reservoir basin has been properly prepared. A particular phase of water level control may be used primarily to destroy mosquito larvae, or it may be directed at vegetation or flotage favorable for mosquito production. A flood surcharge above the upper normal pool level for a few days in the spring prior to the mosquito breeding season followed by a sharp drawdown is effective in stranding objectionable flotage. The invasion of marginal vegetation can be limited by holding the reservoir at a constant level during the early spring growth period. This phase is especially important since it will increase the effectiveness of subsequent fluctuation or recession. Seasonal water level recession used alone or in combination with periodic fluctuation is a very effective control measure since it provides a clean shoreline which is unfavorable for mosquito production.

General Relationships Between Waterfowl Refuges and Vector Problems

Waterfowl refuges often result in conditions which are highly favorable for the production of mosquitoes and other aquatic insects of public health importance. In general, these conditions are the same as those that favor vector production in other types of impoundments. Prolific production of Aedes mosquitoes may occur in waterfowl refuges where water fluctuates, alternately exposing and inundating shallow vegetated areas. Constant water levels with emergent vegetation and floating debris provide favorable aquatic habitats for C. tarsalis, the encephalitis mosquito.

Experience has shown that vector control and wildlife interests are not always antagonistic and that a cooperative approach to construction and management problems may result in the development of practices which are mutually beneficial to both interests. For example, water management practices can sometimes be employed to minimize conditions favorable for mosquito production and at the same time encourage the growth of desirable food and cover plants for waterfowl. When waterfowl refuges are to be developed that have high vector production potentials and preventive or control measures are not practicable, they should be located beyond flight range of recreational areas or human population centers. When it is necessary to locate waterfowl refuges within flight range of human population groups and vector production cannot be controlled, provision should be made for adequate measures to protect prople from adult mosquitoes and other aquatic insects of public health importance.

ANTICIPATED EFFECTS OF THE PROPOSED PROJECT ON VECTOR PROBLEMS

A considerable portion of the shoreline of the Senator Wash Reservoir will be steep with little or no vegetation and exposed to wave action. This type of shoreline will be unfavorable for the production of mosquitoes and other aquatic insects of public health importance and no special vector prevention or control measures would be required in such areas of the reservoir.

The anticipated fluctuation of water levels might result in conditions which would be favorable for the production of Aedes and Psorphora mosquitoes. This would be true if flat vegetated areas are alternately exposed and inundated at intervals which would permit these mosquitoes to complete their aquatic stages. In case of relatively constant reservoir levels, shallow water areas with emergent vegetation or flotage would provide favorable habitats for C. tarsalis. In the event seepage areas develop below the dam or dikes, they would undoubtedly provide favorable habitats for C. tarsalis.